Comments and Response

In view of the comments below Applicant respectively requests that the Examiner reconsider the present application including rejected claims 1-14 and 29-63 and withdraw the rejections of these claims. Applicant notes with agreement that claims 15-28 have been canceled without prejudice.

a. Applicant notes with appreciation that the material provided via supplemental information disclosure statement has been considered and that the form 1449 has been signed and a copy returned.

b. The drawings, specifically FIG. 3B is objected to and a label such as "Prior Art" is required. Figure 3B with the proposed label is included with this amendment and Applicant respectfully submits that this objection has been traversed and therefore requests that it be withdrawn.

c. Claims 1 – 50 are rejected under 35 U.S.C. §112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, to make and/or use the invention. Applicant respectfully notes that claims 15-28 have been canceled without prejudice.

The Examiner maintains that: it is not disclosed that the gate electrode portion in the trench is located "such that the insulation film is located between the inner wall surface and the gate electrode" as recited, variously, by claims 1, 3, 34, and 38. In so far as Applicant can appreciate the Examiners concerns, it appears that the Examiner is concerned with referring to the vertical boundary area between the regions 23, 22, 24 and the insulation region 27 as an inner wall surface. It further appears that the

Examiner would prefer to refer to this surface or boundary as an outer wall surface. However, Applicant respectfully notes that the boundary has been consistently referred to as an inner wall surface throughout the specification and that from the perspective of one in the trench 46 it would reasonably appear as an inner wall surface. In any event since there is only one surface or boundary of interest in this passage that is clearly depicted in numerous figures there is no indefiniteness introduced by this terminology and thus Applicant respectfully requests that the Examiner withdraw this rejection of these claims.

d. Claim 14 recites, "said highly doped first conductivity type region" without providing proper antecedent basis for this element. Applicant respectfully submits that the proposed amendment to claim 1 provide proper antecedent basis for this element and thus requests that the Examiner withdraw this rejection of claim 14.

c. Claim 1-2 and 29 stand rejected under 35 U.S.C. §102 as being anticipated by prior art as admitted in Applicants disclosure. Generally the Examiner refers to Applicants discussion of Prior Art on pages 2 and 3 with reference to FIG. 20-22 and imposes various of these passages on FIG. 3B. Based on this the Examiner construes FIG. 3B to show "said impurity concentration profile of said second conductivity type region changes gently in the depth direction of the semiconductor substrate and has a gentle peak at a depth greater than a junction depth of said first conductivity type region within said second conductivity type region, by virtue of the partial cancellation of n- and p- dopants near the interface of regions 3 and 4 (see Figure 3B) and the monotonically decreasing As and B dopant concentrations;" Applicant respectfully notes that regions 3 and 4 are elements shown in FIG. 20 and 22 with the corresponding dopant concentration depicted in FIG. 21.

Applicant is unable to construe FIG 3B as showing or suggesting a gentle peak in the p type dopant distribution. Furthermore there does not seem to be any gentle change in the depth direction of the impurity concentration depicted in FIG. 3B. In

contrast FIG. 3A shows a gentle peak and as a result of the gentle peak a more gradual or gentle reduction in the concentration in the vicinity of the peak. This may be further contrasted with the sharp peak characteristic shown in FIG. 21. For these reasons Applicant respectfully submits that the Prior Art discussions does not show or suggest the invention as claimed by claim 1. Therefore Applicant respectfully requests that the Examiner reconsider and withdraw this rejection of claim 1 and by virtue of dependency claims 2 and 29.

d. Claims 34-42 and 51-55 stand rejected under 35 U.S.C. §102(e) as being anticipated by Huang (6,110,799). The Examiner maintains that Huang anticipates all elements of claim 34. Specifically, the Examiner maintains that Huang shows "a second trench located in the second conductivity type region and positioned away from the first trench." Applicant respectfully disagrees and notes that the trench 34 of FIG. 8 clearly extends into the substrate or first conductivity layer 10 in Huang rather than being located in the second conductivity region (43 in FIG 8G for example).

Next the Examiner determines that a single buried p+ region 35 in Huang can be divided into two regions given that impurity concentrations vary monotonically according to depth. Given this curious division of one structure into two structures, the Examiner maintains that:

"a second conductivity type protrusion region having a junction depth that is greater than the junction depth of the second semiconductor layer, the protrusion region being positioned beneath the second trench; and

a second conductivity type doped region that has an impurity concentration higher than that of the protrusion region, wherein the second conductivity type doped region has a diffusion depth that is less than the junction depth of the protrusion region, the second conductivity type doped region is positioned beneath the second trench, and the protrusion region encompasses the second conductivity type doped region;" is anticipated by Huang.

Applicant respectfully disagrees. There is no suggestion in any of the references or specifically in Huang that the buried layer 35 may be viewed as two layers. Furthermore, implantation followed by a drive in step does not necessarily result in a monotonically decreasing concentration. For example, depending on the drive in process particulars the concentration of the implanted dopant may increase and only after a peak decrease with depth.

In Huang the p+ region or buried layer 35 comes in contact with the n region structurally, whereas, in the present invention, as recited in claim 34, the p+ region (second conductivity type doped region 74 that has an impurity concentration higher than that of the protrusion region 73) comes in contact the n region via a deep p region (second conductivity type protrusion region 73). In Huang the implantation occurs after forming a second trench (22 in Fig. 3 of Huang) with depth sufficient to reach the n region so that a p+ region of high impurity concentration may be formed. In the present application, as shown in Fig. 8G, after forming a second trench 72 with a depth that nominally reaches halfway through the p region 43 (not enough to reach the n region), ions are implanted to form a deep p region 73 via the second trench 72, and then ions are implanted to form a p region 74 of high impurity concentration to obtain electric contact with the deep p region 73. The present invention is different from Huang for this reason. Applicant respectfully submits that these differences are captured with the claim language defining the second trench 72, the second conductivity type doped region 74, and the protrusion region 73.

These differences are non trivial in terms of impact on the final structure. For example in Huang, because the p+ region 35 is formed directly in contact with the N region by implanting ions at high concentration via the second trench 34, leakage at the p+/n junction tends to occur as a result of damage at the time of processing the trench and also as a result of the highly concentrated ion implantation. In light of overcoming such problems, in the present application, the depth, of the second trench, is set to be a less than the depth and nominally half the depth of the p region 43. Furthermore the two layers: a deep P region 73 and highly concentrated P region 74 in electric contact are formed to reduce damage in processing or providing the p/n junction surface.

For these reasons Applicant respectfully submits that Huang (6,110,799) does not show or suggest the invention as claimed by claim 34 and by virtue of dependency claims 35-37. Therefore Applicant respectfully requests that the Examiner reconsider and withdraw this rejection under 35 U.S.C. §102(e) of claim 34 and dependent claims 35-37 based on Huang (6,110,799).

Regarding claim 38, the Examiner maintains **cont.**

Regarding claim 51, the Examiner maintains that

e. Claims 3-5 and 30 are rejected under 35 U.S.C. §103(a) as being unpatentable over the Prior Art as disclosed by Applicants in view of Huang (6,110,799). Claim 3 defines a semiconductor device that comprises, among other limitations:

a plurality of second trenches formed inside said second conductivity type region so that each of the second trenches is positioned between an adjacent pair of said first trenches;

a second conductivity type protrusion region, which protrudes downwardly, wherein the second conductivity type protrusion region forms a junction that is deeper than a junction of said second conductivity type region, the protrusion region being positioned beneath the second trench; and

a second conductivity type highly doped region having an impurity concentration higher than that of the protrusion region, wherein the depth of the second conductivity type highly doped region is less than that of the junction of said protrusion region, the second conductivity type highly doped region is located beneath the second trench, and wherein the protrusion region encompasses the second conductivity type highly doped region.

As noted above with regard to claim 34 the second trenches 34 shown by Huang are not formed inside the second conductivity type region 14 but rather extend to the substrate 10 (see Huang FIG. 8-9). As also noted in reference to claim 34 the second conductivity type protrusion region 73 and the second conductivity type highly doped region 74, each as claimed, are not shown or suggested by the buried layer 35 of Huang. Since the Prior Art as known to Applicant and the references that have been cited,

specifically Huang, do not whether taken alone or in combination show all elements of claim 3 as noted here and in further detail above with reference to claim 34, Applicant respectfully submits that claim 3 and claims dependent thereon, specifically 4-5 as well as 6-10, 30, and 31-32 have not been rendered unpatentable under 35 U.S.C. §103(a). Thus Applicant respectfully requests that the Examiner reconsider claims 3-5 and 30 and withdraw this rejection.

f. Claims 6-10 and 31-32 are rejected under 35 U.S.C. §103(a) as being unpatentable over Prior art as admitted by Applicants over Huang as applied to claim 3 above, and further in view of Yu et al (6,213,869 B1). As detailed above claim 3 is unpatentable over Prior Art as admitted by Applicants in view of Huang.

g. Claims 11-14 and 33 are rejected under 35 U.S.C. §103(a) as being unpatentable over Prior Art as admitted by Applicants in their disclosure (pages 2-3 and Fig. 22B) in view of So et al (5,895,951). As detailed above, Prior Art as admitted by Applicants anticipates claim 1.

h. Claims 35-36, 43-50 and 56-63 are rejected under 35 U.S.C. §103(a) as being unpatentable over Huang (6,11,799) in view of Prior art as admitted by applicant. Haung anticipated claims 34, 38 and 51. Huang does not necessarily teach the further limitations of claims 35-36, 43-50 and 56-63. However, it is understood in the art of vertical MOS devices that the drain electrode, inherently present in such devices is a lower electrode contacting a semiconductor layer on the lower main face of the semiconductor wafer.

Accordingly, applicant respectfully submits that the claims, as amended, clearly and patentably distinguish over the cited reference of record and as such are to be deemed allowable. Such allowance is hereby earnestly and respectfully solicited at an early date. If the examiner has any suggestions or comments or questions, calls are welcomed at the phone number below.

Although it is not anticipated that any fees are due or payable, the Commissioner is hereby authorized to charge any fees that may be required to Deposit Account No. **50-1147**.

Respectfully submitted,

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Charles W. Bethards
Reg. No. 36,453

Law Office of David G. Posz
2000 L Street, N.W.
Suite 200
Washington, D.C. 20036
Phone (202) 416-1638
Fax (202) 416-1639
Customer No. 23400